

# ASSIMILATION OF SMOS RETRIEVED SOIL MOISTURE INTO THE LAND INFORMATION SYSTEM

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## 1. BACKGROUND

Soil moisture is a crucial variable for weather prediction because of its influence on evaporation and surface heat fluxes [3]. It is also of critical importance for drought and flood monitoring and prediction and for public health applications such as monitoring vector-borne diseases. Land surface modeling benefits greatly from regular updates with soil moisture observations via data assimilation. Satellite remote sensing is the only practical observation type for this purpose in most areas due to its worldwide coverage. The newest operational satellite sensor for soil moisture is the Microwave Imaging Radiometer using Aperture Synthesis (MIRAS) instrument aboard the Soil Moisture and Ocean Salinity (SMOS) satellite [11]. The NASA Short-term Prediction Research and Transition Center (SPoRT) [5, 13] has implemented the assimilation of SMOS soil moisture observations into the NASA Land Information System (LIS), an integrated modeling and data assimilation software platform [8, 9, 12]. We present results from assimilating SMOS observations into the Noah 3.2 land surface model [4, 6] within LIS.

The SMOS MIRAS is an L-band radiometer launched by the European Space Agency in 2009, from which we assimilate Level 2 retrievals [1] into LIS-Noah. The measurements are sensitive to soil moisture concentration in roughly the top 2.5 cm of soil. The retrievals have a target volumetric accuracy of 4% at a resolution of 35-50 km. Sensitivity is reduced where precipitation, snowcover, frozen soil, or dense vegetation is present. Due to the satellite's polar orbit, the instrument achieves global coverage twice daily at most mid- and low-latitude locations, with only small gaps between swaths.

## 2. METHODOLOGY

The modular architecture of the LIS package makes it relatively straightforward to add new observation operators to LIS. The new code reads SMOS Level 2 Soil Moisture User Data Product files from the ESA and performs quality control based on SMOS data flags including tests for precipitation,

radio frequency interference, and retrieval quality, as well as model-based quality control checks for precipitation, snowcover, and frozen soil. It includes a forward operator for predicting the SMOS observations based on model state. Data assimilation is done via the Ensemble Kalman Filter algorithm within LIS (EnKF) [9], which uses the spread in an ensemble of model runs to represent the model error. The ensemble spread is achieved by applying some combination of state, forcing, and observation perturbations. Each ensemble member is updated with the SMOS observations, with the weighting between model background and observations governed by the relative size of the model error (ensemble spread) and specified observation error.

As a first step in assimilating SMOS observations, synthetic observations with a highly artificial structure consisting of rectangular blocks of constant low and high soil moisture are assimilated into the LSM. This provides a sanity check to make sure the innovations (observations minus model-predicted observations) and model increments are reasonable. Next, the perturbations are tuned empirically to give a reasonable ensemble spread.

Finally, assimilation experiments are performed with operational SMOS data. Since previous work (using the AMSR-E sensor) suggested it is difficult to show improvement from data assimilation when using precipitation forcing from radar and rain-gauge networks [2], we performed an experiment using intentionally degraded precipitation forcing. Parallel simulations with and without SMOS assimilation are run with the degraded forcing, and then validated against a model run using the best available precipitation data, as well as against selected station observations. This will demonstrate the benefit of SMOS data assimilation in the absence of dense rain gauge and radar networks (of interest for sparsely instrumented regions and for global applications).

### **3. RESULTS AND FUTURE WORK**

Preliminary results from the assimilation of a sample swath of SMOS soil moisture retrievals over the Eastern US are shown in Figure 1. The left and right panels show the top layer (0-10 cm) modeled soil moisture before and after the assimilation, with the quality-controlled surface soil moisture observations (retrievals) in the center panel. Prior to tuning the ensemble spread, we obtain reasonable innovations and analysis increments. Further tuning of the ensemble spread will be conducted to optimize the soil moisture assimilation to produce a reasonable and accurate blend of the model background and SMOS retrievals. Future plans are to perform further testing and validation with high-quality precipitation forcing in order to explore the benefits of SMOS data assimilation in areas with dense radar and rain

gauge networks. Furthermore, assimilation of retrievals from SMOS will help prepare for the rapid implementation of observations from NASA's Soil Moisture Active/Passive (SMAP) satellite, planned for launch in 2014 [7].

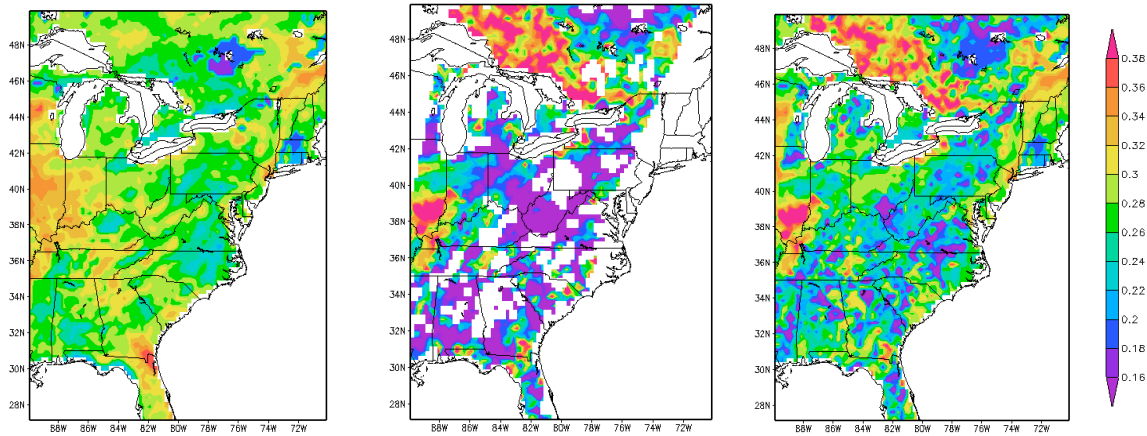


Figure 1. Left: Top layer (0-10 cm) Noah modeled soil moisture at 00 UTC 5 Jun 2013, before assimilation. Center: Observed (retrieved) surface soil moisture from SMOS. Right: Noah soil moisture 3 hours later, after innovation.

## 11. REFERENCES

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